THE CONVERSION OF THE ENERGY OF CARBON INTO ELECTRICAL ENERGY ON SOLUTION IN IRON.

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In molten iron carbon dissolves with a liberation of energy, which, by providing a suitable negative electrode, may be obtained in the form of an electric current. The resulting electromotive force is quite small, but is clearly to be distinguished from the accompanying thermo-electric effect.

The experiment about to be described was, in outline, to set up a voltaic cell consisting of electrodes of wrought iron and carbon immersed in a bath of molten iron or steel of a low carbon content. Such an experiment is beyond the equipment of an ordinary laboratory, and for its execution I am indebted to the courtesy of Dr. Geo. W. Sargent, of the Carpenter Steel Company, Reading, Pa., who placed the necessary facilities at my disposal.

The ideal liquid for such a cell would be a carbonless iron, just as fresh acid in an ordinary cell is more effective than one which already contains some zinc in solution; but the melting point of such iron is too high to be reached in a steel furnace. It was, therefore, necessary to employ a low carbon steel. On account of its higher melting point wrought iron furnishes a convenient material for the negative element.

The positive element was built up of three carbon rods, such as are used in arc lights, wired firmly to a copper rod at their upper ends. Two such electrodes were prepared in case one should crack in the melted metal. To minimize as much as possible the danger of cracking, the carbon was gradually heated by placing it at first near, and finally in, an empty red-hot crucible. In this way the tips of the rod were made red hot.

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Having no milli-voltmeter at my disposal it was necessary to use a milliammeter, which of course is equivalent to the other if the resistance of the circuit is known. Connections were made to the ammeter on the supposition that the current would leave the cell by the wrought iron electrode and return by the carbon. Care was taken, however, to insert a reversing key in the circuit.

About ninety pounds of a low carbon steel (0.10 per cent.) were placed in a crucible and heated for about four hours. Perfect fluidity could not be obtained, but the mass finally became pasty and viscous, allowing a rod of iron to be plunged into it without great difficulty. A small amount of aluminium was then added to free the mass from gas bubbles, and the crucible was then withdrawn from the furnace, placed on the floor and banked about with coal, which immediately took fire. As quickly as possible, for the metal rapidly hardened, the electrodes were plunged in while a watch was kept at the ammeter.

Almost immediately the carbon electrode snapped off at the surface of the metal, and so rapid was the cooling that by the time the spare carbon electrode could be brought into action the metal was too hard to allow it to be plunged in; but the small fraction of a second available to the watcher at the ammeter was sufficient.

Immediately on plunging in the carbon electrode the pointer of the ammeter started to move in the expected direction. When the carbon cracked the reading was 0.015 ampere. The pointer then fell back and exhibited a tendency to a reverse deflection. Turning the reversing key, the pointer again moved forward and remained stationary at about one third of its previous reading. On looking at the crucible it was found that the upper portion of the electrode was lying loosely upon the surface of the now solid, though still red-hot metal. On lifting the electrode the deflection disappeared, but reappeared as often as the carbon was touched to the hot metal or even to the (now hot) iron electrode. This deflection was plainly of a thermo-electric origin, while the earlier deflection in the opposite direction is to be explained only as the result of galvanic action.

How far the pointer would have moved had the carbon not cracked it is, of course, impossible to say. Neither is it possible to be certain as to the voltage corresponding to the observed reading of 0.015 ampere. The resistance of the ammeter and lead wires together was less than one ohm, and the uncertainty lies in the resistance of the hot metal and the contacts with it. The electrodes were about 15 cm. apart, and the crucible had a diameter of some 25 cm., so that, although the temperature was high, the resistance must have been very small. One ohm would probably be a liberal allowance. Assuming a total resistance of two ohms in circuit, the voltage would have been 0.03.

On general principles, we should expect that any such voltage would be very small. That there is any liberation of energy at all when carbon dissolves in melted iron indicates that the act of solution is, at least in part, chemical, and points to the existence of a new carbide of iron, stable at high temperatures, and of a simpler molecular formula and greater energy content than the well known carbide Fe_3C, which is stable only below a red heat, just as CO stands between CO_2 and free carbon and oxygen. Now the heat of formation of Fe_3C is not known, but its energy content must be but little less than that of its constituents in a free state; and consequently the margin of liberated energy at the formation of the hypothetical simpler carbide must be extremely small.

Further experiments on this matter are in progress.